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| **GENETIC PROCESSES Grade 11 (SBI 3U)** | | |
| ***Lesson Sequence*** | ***Lesson Plan Title (Concept)*** | ***Names*** |
| First Lesson | Codominance and Incomplete Dominance | Katie Clay and Lauren Cluff |
| Wet Lab | Blood Typing (codominance) | n/a |
| Second Lesson | Sex Linkage and Sex-Linked Genetic Disorders | Silvia De Sousa and Sasha Moldovan |
| ***Rationale:***  These two lessons appear on Days 12 and 14 of our unit plan. There is a “Blood Typing” wet laboratory on codominance in between the two lessons.  These two lessons help to develop the Big Idea that “variability and diversity of living organisms result from the distribution of genetic materials during the process of meiosis.” Genetic traits governed by codominance, incomplete dominane and sex-linkage all contribute to variability and diversity of organisms such as humans (discussed in second lesson), flowers, chicken (discussed in first lesson), and others. The first and second lessons also discuss how different genes that follow these non-Mendelian patterns may be distributed during meiosis through the use of Punnett squares.  The Big Idea, “genetic and genomic research can have social and environmental implications” is touched upon in the second lesson with discussion of various sex-linked genetic disorders that affect people in our society and all over the world. | | |

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| **Grade 11 Biology SBI 3U** | | | |
| NAMES: Katie Clay and Lauren Cluff | | | |
| UNIT: Genetic Processes TITLE OF LESSON : Co-dominance and Incomplete Dominance | | | |
| **BIG IDEAS**:  - variability and diversity of living organisms result from the distribution of genetic materials during the process of meiosis | | **MATERIALS**:   * Computer with internet access and projector * Student Handouts * Flower showing co-dominance * Exit cards | |
| **MINISTRY EXPECTATIONS**:  D2.3- use the Punnett square method to solve basic genetics problems involving monohybrid crosses, incomplete dominance, co-dominance, dihybrid crosses, and sex-linked genes  D2.4- investigate, through laboratory inquiry or computer simulation monohybrid and dihybrid crosses and us the Punnett square method and probability rules to analyze the qualitative and quantitative data and determine the parent genotype  D3.3- explain the concepts of genotype, phenotype, dominance, incomplete dominance, co-dominance, recessiveness and sex linkage according to Mendelian laws of inheritance | |
| **STUDENT LEARNING GOALS**:  -students will understand the concept of incomplete dominance and co-dominance  -students will be able to solve problems involving incomplete dominance and co-dominance using Punnett squares | | APPENDICES  A 1) Vocabulary Student Handout  A 2) Vocabulary Teacher Handout  A 3) Introduction Questions for projector  B 1) Student Handout – Gizmo Activity  B 2) Teacher Answer Key – Gizmo Activity  B 3) Chalkboard notes  B 4) Student handout – notes  C 1) Exit Card – KWL | |
| PRIOR KNOWLEDGE:  -students have an understanding of Mendelian genetics and dominance (from days 1-11 of the unit)  -they know how to use Punnett squares to find probabilities of genotypes and phenotypes for both monohybrid and dihybrid crosses (days 10-11 in unit) | |
|  | T/L STRATEGIES | RATIONALE | ASSESSMENT |
| A MINDS ON  (10-15min) | 1) Web – previous words and knowledge about genetics – use vocabulary list  **Appendix A 1) and A 2)** | Review previous terms and concepts, link prior knowledge to today’s lesson | Students provide words and definitions which shows their understanding |
| 2) Examine flower with two different colours of petals – students think, pair share to answer introductory questions on projector  **Appendix A 3)** | Introduce co-dominance through hands on example and discussion | Think, pair, share - Students share ideas with the class |
| B ACTION  (25-30min) | 1) Gizmos – Chicken Genetics  - the use of this gizmo will introduce the concept of co-dominance  - Gizmo performed at front of class using volunteers  - class will follow along and answer questions  **Appendix B 1) and B 2)** | - Interactive, self-discovery of co-dominance  -allows students to explore new concept before ‘being told’  - Incorporates many different learning styles | Check answers with peers and discuss any problems with class |
| (15-20min) | 2) Notes on co-dominance, incomplete dominance, multiple allelism  - students will fill in handouts  **Appendix B 3) and B 4)** | -to give students an opportunity to see the concepts written in words as well as keep as a reference for future studying  -appeal to visual/verbal learners | Questioning during note taking |
| C CONSOLID-ATION &  CONNEC-TION  (10-15) | 1)Blood typing applications  - get students to work in groups of 4 to brainstorm ideas on how blood typing can be useful in real life – health, forensics, etc | -Get students to connect concepts with real world applications  -invite peer discussion to allow for higher order learning | -Walk around class and listen to students various ideas  -Ask students to share with class if time allows |
| 2) KWL – exit card  **Appendix C 1)** | - allows students to anonymously express their concerns  -identifies where improvement can be made and what needs to be clarified | -examine student feedback |
| NEXT STEPS | -Tomorrow we will do the blood typing lab followed by x-linkage and pedigrees  -Complete the question on the student handout for HomeFun! |  |  |

**Appendix A 1)**

**GENETICS VOCABULARY**

Please, write definitions for the following terms in genetics as we go through this unit. You may refer to the glossary, which can be found at the back of your textbook. Try to write the definitions in your words.

**Allele** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Autosomal inheritance** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Autosome** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Barr body** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Co-dominance –** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Dihybrid cross** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Dominant** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Expression** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**F1 generation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**F2 generation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Gene** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Genetics** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Genome** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Genomics** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Genotype** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Haploid** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Heterozygous** - \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Homozygous** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Incomplete dominance** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Karyotype** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Law of independent assortment** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Law of segregation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Linked genes** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Mendelian ratio** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Monohybrid cross** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Multiple alleles** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Order of dominance** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**P generation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Pedigree** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Phenotype** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Polygenic trait** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Probability** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Punnett square** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Recessive** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Sex chromosome** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Sex-linked trait** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Test cross** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Trait** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**True breeding** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Variation** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**X-linked gene** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Appendix A 2)**

**GENETICS VOCABULARY Teacher Copy**

**Allele** – one of two or more forms of a gene

**Autosomal inheritance** – the inheritance of traits determined by genes on the autosomal chromosomes

**Autosome** – a chromosome that is not involved in determining the sex of an organism

**Barr body** – of the two X chromosomes in the cells of a female individual, the one that is inactivated at an early embryonic stage

**Codominance –** the condition in which both alleles for a trait are equally expressed in a heterozygote; both alleles are dominant

**Dihybrid cross** – a cross of two individuals that differ in two traits due to two different genes

**Dominant** – describes the form of a trait that always appears when an individual has an allele for it; an allele that causes expression of a phenotype whenever it is present

**Expression** – the production of a particular protein from a gene; also the level of production of a particular protein from a gene

**F1 generation** – the first filial generation; the offspring of a cross of the P generation

**F2 generation** – the second filial generation; the offspring of a cross between individuals from the F1 generation

**Gene** – a part of a chromosome that governs the expression of a trait and is passed on to offspring; it has a specific DNA sequence

**Genetics** – the field of biology that involves the study of heredity and variation of living organisms and how genetic information is passed from one generation to the next

**Genome** – the complete DNA sequence of an organism

**Genomics** – the study of genomes and the complex interactions of genes that result in phenotypes

**Genotype** – the combination of alleles for any given trait, or the organism’s entire genetic make-up

**Haploid** – describes a cell that contains half the number of chromosomes as the parent cell

**Heterozygous** - an organism that has two different alleles of a gene

**Homozygous** – describes an organism that has two identical alleles of a gene

**Incomplete dominance** – a condition in which neither allele for a gene completely conceals the presence of the other; it results in intermediate expression of a trait

**Karyotype** – a photograph of pairs of homologous chromosomes in a cell

**Law of independent assortment** – the law that states that during gamete formation, the two alleles for one gene segregate or assort independently of the alleles for other genes

**Law of segregation** – the law that states that traits are determines by pairs of alleles that segregate during meiosis so that each gamete receives one allele

**Linked genes** – genes that are on the same chromosome and that tend to be inherited together

**Mendelian ratio** – a ratio of offspring phenotypes reflecting Gregor Mendel’s law of inheritance

**Monohybrid cross** – a cross of two individuals that differ by one trait

**Multiple alleles** – more than two alleles for one gene

**Order of dominance** – the sequence that describes the dominance relationship between alleles for a gene that has multiple alleles; greater than (>) means *is dominant to* and less than (<) means *is recessive to*

**P generation** – the parental generation; in breeding, the organisms that are initially crossed and are typically true breeding

**Pedigree** – a flowchart that uses symbols to show the inheritance patterns of traits in a family over many generations

**Phenotype** – the physical and physiological traits of an organism

**Polygenic trait** – a trait that is controlled by more than one gene

**Probability** – the chance or likelihood of a particular outcome; usually expressed as a ratio

**Punnett square** – a grid used to illustrate all possible genotypes and phenotypes of offspring from genetic crosses

**Recessive** – describes the form of trait that only appears when an individual has two alleles for it; an allele that must be present in two copies for the phenotype to be expressed

**Sex chromosome** – an X or Y chromosome, which determines the genetic sex of an organism

**Sex-linked trait** – a trait controlled by genes on the X or Y chromosome

**Test cross** – a cross between a parent of unknown genotype and a homozygous recessive parent

**Trait** – a specific feature or characteristic exhibited by an organism

**True breeding** – describes organisms that exhibit the same traits, generation after generation

**Variation** – differences between individuals, which may be structural, functional or physiological

**X-linked gene** – a gene that is found on the X chromosome

**Appendix A 3)**

**MINDS ON**

**Prior Knowledge Questions**

[](http://upload.wikimedia.org/wikipedia/commons/c/c7/Flower_374.jpg)

1. The image, similar to the flower presented in class,

shows a flower that was produced by crossing a pure

red flower with a pure white flower. Which do you think

is the dominant petal colour: red or white? Explain.

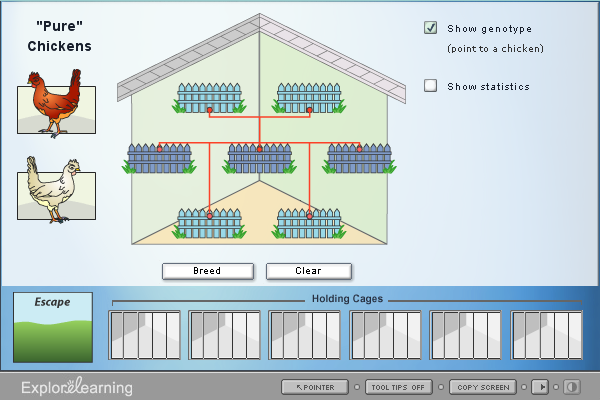
1. How is the inheritance pattern shown by this flower different from other inheritance patterns you have seen or studied?

**Appendix B 1)**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Student Exploration: Chicken Genetics**

**Gizmo Warm-up**



There are many different ways traits can be inherited. Some traits are governed

by **alleles** that are **dominant** over other alleles. Other traits are governed by

alleles that share dominance. These alleles follow a pattern of inheritance

called **co-dominance**. With the *Chicken Genetics* Gizmo™, you will study how

co-dominance affects the inheritance of certain traits.

1. Turn on **Show genotype**. The **genotype** is the allele combination an

organism has. Point to the red chicken.

1. What is the red chicken’s genotype? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is the white chicken’s genotype? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What do you think the letters *F, R,* and *W* stand for in the genotypes?

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| **Activity A:**  **Co-dominant traits** | Get the Gizmo ready:   * Drag a red chicken and a white chicken into the parent boxes, but don’t click **Breed** yet. |  |

**Question: What inheritance patterns do co-dominant traits display?**

1. Predict: What do you think the offspring of a red chicken and a white chicken will look like?

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1. Observe: Click **Breed**. What are the offspring genotypes? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

An organism’s appearance is its **phenotype**. Describe the offspring’s phenotype.

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1. Experiment: Drag four offspring to the **Holding Cages**. Click **Clear**, and then drag one of the offspring to a parent box. Drag a white chicken to the other box. Click **Breed** several times.

Describe the resulting genotypes and phenotypes of the offspring.

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1. Revise and Repeat: Click **Clear**. Drag another chicken from the **Holding Cages** to the parent box. Drag a red chicken to the other box. Click **Breed** several times.

Describe the resulting genotypes and phenotypes of the offspring.

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1. Explain: In dominant/recessive inheritance patterns, the dominant allele is always expressed when present. The **recessive** allele is only expressed when the dominant allele is not present. Use your observations from this activity to describe how co-dominant inheritance patterns differ from dominant/recessive inheritance patterns.

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| **Activity B:**  **Co-dominant crosses** | Get the Gizmo ready:   * Click **Clear**. * Drag the remaining chickens from the **Holding Cages** into the parent boxes. |  |

**Introduction: Probability** is the likelihood that a specific event will occur. Scientists use probability to predict the outcomes of different genetic crosses.

**Question: How can you use probability to predict the outcome of a co-dominant cross?**

1. Model: A **Punnett square** is used to model the possible offspring genotypes from a genetic cross. The parent genotypes are written at the top and side of the square, as shown. The possible offspring genotypes are then filled in.

|  |  |  |
| --- | --- | --- |
|  | ***FR*** | ***FW*** |
| ***FR*** | ***FR FR*** |  |
| ***FW*** |  |  |

The first square is filled in for you. Fill in the remaining squares. (Note: *FR FW* is equivalent to *FW FR*.)

­­­­

1. Analyze: A **homozygous** chicken will have the same alleles for feather color. A **heterozygous** chicken will have two different alleles for feather color.
   * 1. Are the parents homozygous or heterozygous? Explain how you know.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* + 1. What are the possible genotypes of the offspring? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    2. Will the offspring be homozygous or heterozygous? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Calculate: Punnett squares can be used to predict probable outcomes of genetic crosses. To calculate probability, divide the number of one kind of possible outcome by the total number of all possible outcomes. For example, if you toss a coin, the chance it will land on heads is equal to 1 ÷ 2. This probability can be expressed as ½, 0.5, or 50%.

Look at the Punnett square above.

* + 1. How many total possible outcomes are there? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    2. How many of the possible outcomes are for each of the following genotypes?

*FR FR* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *FW FW* \_\_\_\_\_\_\_\_\_\_\_\_\_ *FR FW* \_\_\_\_\_\_\_\_\_\_\_\_\_

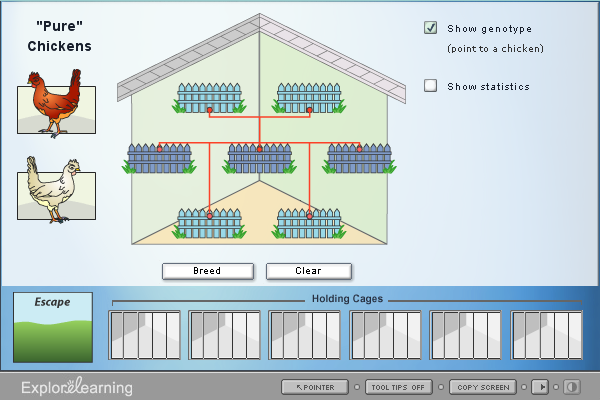
* + 1. What is the probability for each of the following outcomes? (Record answers as both fractions and percentages.)

*FR FR* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *FW FW* \_\_\_\_\_\_\_\_\_\_\_\_\_ *FR FW* \_\_\_\_\_\_\_\_\_\_\_\_\_

**Appendix B 2)**

**Chicken Genetics Answer Key**

**Gizmo Warm-up**



There are many different ways traits can be inherited. Some traits are governed

by **alleles** that are **dominant** over other alleles. Other traits are governed by

alleles that share dominance. These alleles follow a pattern of inheritance

called **co-dominance**. With the *Chicken Genetics* Gizmo™, you will study

how co-dominance affects the inheritance of certain traits.

1. Turn on **Show genotype**. The **genotype** is the allele combination an

organism has. Point to the red chicken.

1. What is the red chicken’s genotype? FR FR
2. What is the white chicken’s genotype? FW FW
3. What do you think the letters *F, R,* and *W* stand for in the genotypes?

*Answers will vary. [*F *stands for feather*, R *stands for red*, *and* W *stands for white.]*

|  |  |  |
| --- | --- | --- |
| **Activity A:**  **Co-dominant traits** | Get the Gizmo ready:   * Drag a red chicken and a white chicken into the parent boxes, but don’t click **Breed** yet. |  |

**Question: What inheritance patterns do co-dominant traits display?**

1. Predict: What do you think the offspring of a red chicken and a white chicken will look like?

*Predictions will vary. Sample answer: If they follow a dominant/recessive inheritance pattern, they will either be red or white.*

1. Observe: Click **Breed**. What are the offspring genotypes? *All are* FR FW

An organism’s appearance is its **phenotype**. Describe the offspring’s phenotype.

*The offspring have a mix of white and red feathers.*

1. Experiment: Drag four offspring to the **Holding Cages**. Click **Clear**, and then drag one of the offspring to a parent box. Drag a white chicken to the other box. Click **Breed** several times.

Describe the resulting genotypes and phenotypes of the offspring.

*About half of the offspring have the genotype* FR FW *and a phenotype of* *red and white feathers. The rest of the offspring have the genotype* FW FW *and a phenotype of pure white feathers.*

1. Revise and Repeat: Click **Clear**. Drag another chicken from the **Holding Cages** to the parent box. Drag a red chicken to the other box. Click **Breed** several times.

Describe the resulting genotypes and phenotypes of the offspring.

*About half of the offspring have the genotype* FR FW *and a phenotype of* *red and white feathers. The rest of the offspring have the genotype* FR FR *and a phenotype of pure red feathers.*

1. Explain: In dominant/recessive inheritance patterns, the dominant allele is always expressed when present. The **recessive** allele is only expressed when the dominant allele is not present. Use your observations from this activity to describe how co-dominant inheritance patterns differ from dominant/recessive inheritance patterns.

*In co-dominant inheritance patterns, both of the inherited alleles are dominant. Thus, both of the alleles show up in the organism’s phenotype.*

|  |  |  |
| --- | --- | --- |
| **Activity B:**  **Co-dominant crosses** | Get the Gizmo ready:   * Click **Clear**. * Drag the remaining chickens from the **Holding Cages** into the parent boxes. |  |

**Introduction: Probability** is the likelihood that a specific event will occur. Scientists use probability to predict the outcomes of different genetic crosses.

**Question: How can you use probability to predict the outcome of a co-dominant cross?**

|  |  |  |
| --- | --- | --- |
|  | ***FR*** | ***FW*** |
| ***FR*** | ***FR FR*** | **FR FW** |
| ***FW*** | **FR FW** | **FW FW** |

1. Model: A **Punnett square** is used to model the possible offspring genotypes from a genetic cross. The parent genotypes are written

at the top and side of the square, as shown. The possible

offspring genotypes are then filled in.

The first square is filled in for you. Fill in the remaining squares.

(Note: *FR FW* is equivalent to *FW FR*.)

­­­­­­

1. Analyze: A **homozygous** chicken will have the same alleles for feather color. A **heterozygous** chicken will have two different alleles for feather color.
2. Are the parents homozygous or heterozygous? Explain how you know.

*They are heterozygous because they have two different alleles for feather color.*

1. What are the possible genotypes of the offspring? FR FR, FW FW, *and* FR FW
2. Will the offspring be homozygous or heterozygous? *Both are possible.*
3. Calculate: Punnett squares can be used to predict probable outcomes of genetic crosses. To calculate probability, divide the number of one kind of possible outcome by the total number of all possible outcomes. For example, if you toss a coin, the chance it will land on heads is equal to 1 ÷ 2. This probability can be expressed as ½, 0.5, or 50%.

Look at the Punnett square above.

* + 1. How many total possible outcomes are there? *Four*
    2. How many of the possible outcomes are for each of the following genotypes?

*FR FR* *One*  *FW FW* *One* *FR FW* *Two*

* + 1. What is the probability for each of the following outcomes? (Record answers as both fractions and percentages.)

*FR FR* *¼, 25%* *FW FW* *¼, 25%* *FR FW* *½, 50%*

**Appendix B 3) Chalkboard Notes**

**Co-Dominance and Incomplete Dominance**

**Co-Dominance** – complete expression of two different alleles of a gene in a heterozygote

Ex. Different feather colours of chickens – Gizmo example from class

**Multiple Allelism** - when there are more than two possible alleles for a given gene (at a specific locus)

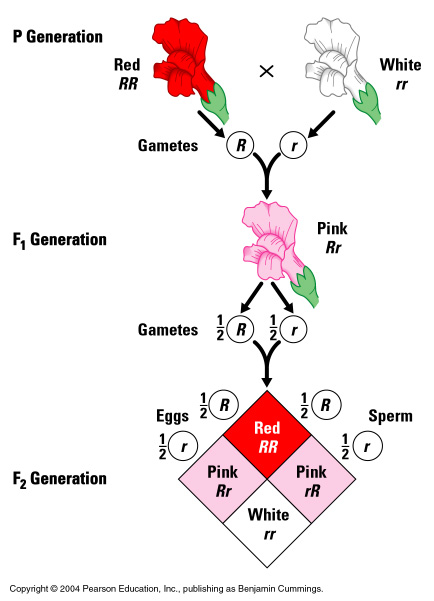
Ex. Blood types

Your blood type is determined by a pair of alleles, but there are three different alleles that may be found at the locus on either of the homologous chromosomes. This results in a large number of possible genotypic combinations and a greater variety of phenotypes. The principle of segregation still operates. The allele for A is represented by IA , B is IB , and both of these are co-dominant over O which is represented by i. Neither IA nor IB can dominate over each other. The chart below represents how the phenotypes and genotypes relate.

|  |  |
| --- | --- |
| Phenotype | Genotype |
| O | Ii |
| A | IAIA or IAi |
| B | IBIB or IBi |
| AB | IAIB |

**Incomplete dominance** – incomplete expression of two different alleles of a gene in a heterozygote; results in intermediate expression

* Neither gene is completely dominant over the other
* The alleles appear to be blending but it is important to note that they are in fact distinct alleles and can be separated out in the F2 generation



Many traits in humans show incomplete dominance such as: hair, skin and eye colours.

**Appendix B 4) Student Handout**

**Co-Dominance and Incomplete Dominance**

**Co-Dominance**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ex. Different feather colours of chickens – Gizmo example from class

**Multiple Allelism:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

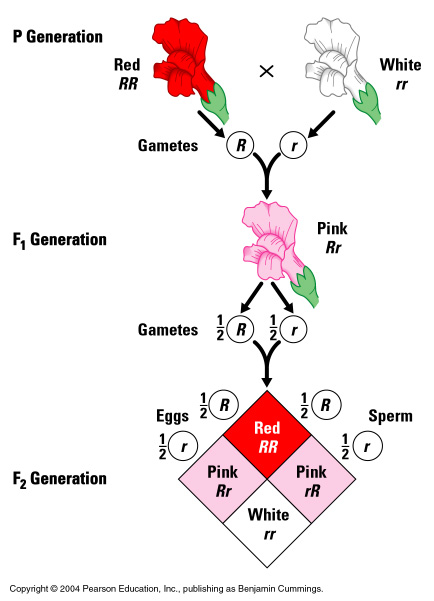
Ex. Blood types

Your blood type is determined by a pair of alleles, but there are three different alleles that may be found at the locus on either of the homologous chromosomes. This results in a large number of possible genotypic combinations and a greater variety of phenotypes. The principle of segregation still operates. The allele for A is represented by \_\_\_\_, B is \_\_\_\_, and both of these are co-dominant over O which is represented by \_\_\_. Neither IA nor IB can dominate over each other. The chart below represents how the phenotypes and genotypes relate.

|  |  |
| --- | --- |
| Phenotype | Genotype |
| O |  |
| A |  |
| B |  |
| AB |  |

**Incomplete dominance:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Neither gene is completely dominant over the other
* The alleles appear to be blending but it is important to note that they are in fact distinct alleles and can be separated out in the F2 generation



Many traits in humans show incomplete dominance such as: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Homework Question**: The colour of feathers in birds is often determined by genes that exhibit incomplete dominance. For example the gene for black feathers, B, may be incompletely dominant to the gene for white feathers, b. The heterozygous condition produces a bird with blue feathers. Determine the genotypic and phenotypic ratios that will result from each of the following crosses:

* + - 1. Blue x white
      2. Black x blue
      3. Blue x blue

**Appendix** **C 1)**

Exit card – Co-dominance and Incomplete Dominance

|  |  |  |
| --- | --- | --- |
| Know | Want to Know | Learned |
|  |  |  |